

# **INTER- AND INTRA INDIVIDUAL VARIATION IN EARPRINTS**

**LYNN MEIJERMAN**

Inter- and intra-individual variation in earprints

Meijerman, Lynn

Thesis University Leiden – With Ref.

ISBN-10: 90-806456-9-9

ISBN-13: 978-90-806456-9-1

© 2006 L. Meijerman, Leiden, the Netherlands. All rights reserved. No part of this book may be reproduced or transmitted, in any form or by any means, without the written permission of the author.

Published by Barge's Anthropologica, Leiden

Printed by GrafiMedia, Leiden

# **INTER- AND INTRA INDIVIDUAL VARIATION IN EARPRINTS**

Proefschrift  
ter verkrijging van  
de graad van Doctor aan de Universiteit Leiden,  
op gezag van de Rector Magnificus Dr. D.D. Breimer,  
hoogleraar in de faculteit der Wiskunde en  
Natuurwetenschappen en die der Geneeskunde,  
volgens besluit van het College voor Promoties  
te verdedigen op woensdag 15 februari 2006  
klokke 15.15 uur

door

Linda Meijerman  
geboren te Borne in 1969

## **PROMOTIECOMMISSIE**

### *Promotor*

Prof. dr. G.J.R. Maat

### *Referenten*

Prof. dr. B. Hillen

Universitair Medisch Centrum St. Radboud, Nijmegen

Ir. R.J. van Munster

Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek TNO, Delft

### *Overige leden*

Prof. dr. A.C. Gittenberger-de Groot

Dr. R. Visser

Nederlands Forensisch Instituut, Den Haag

The work presented in this thesis has been carried out at the Department of Anatomy and Embryology of the Leiden University Medical Center, the Netherlands, within the framework of the FearID project. This shared-cost Research and Technological Development project was funded under the 5th Framework Programme of the European Community (Competitive and Sustainable Growth Programme, Measurements and Testing Activity, Contract G6RD-CT-2001-00618).

Financial support by Stichting ter financiering van Barge's Anthropologica and the Department of Anatomy and Embryology of the Leiden University Medical Center for the publication of this thesis is gratefully acknowledged.

*Aan Herman*

*Aan mijn ouders en grootouders*



## **PREFACE**

Fingerprints are well-known as a tool for person identification in forensic investigations. But fingers are not the only parts of the body that may leave characteristic imprints on a crime scene. In 1987, the Dutch police force intended to expand their expertise on body trace evidence. Chief inspector of police Cor van der Lugt of the Police Academy of the Netherlands was asked to summarize from literature the various body traces that may be left by perpetrators of crimes, and investigate their potential for individualization. This is when his interest in earprints started to develop. During the following years, he endeavoured to demonstrate the potential of earprints for forensic research. His efforts to study the value of earprints culminated in 2001 in approved funding from the European Commission for 'FearID', an international research project aimed at the individualization of earprints. In February of 2002, nine institutes from Italy, the Netherlands and the UK – among which the Leiden University Medical Center – joined their research forces to investigate the potential of earprints for forensic investigations. The work presented here was carried out in the context of this research project.

Whether or not earprints may provide a valuable additional tool in forensic research will depend on a number of factors. On the practical side of things, one would not only need an extensive database of earprints, but also a computer programme that can – (semi) automatically and with an acceptable rate of false matching – group earprints that may have been left by a single ear. Developing such a computer programme requires the application of advanced image-processing techniques as well as a suitable set of measurable or classifiable features, and was part of the task the FearID research team had set out to accomplish.

A fundamental aspect of the question whether earprints may be used in forensic investigations – particularly when adduced as evidence in a court of law – is the issue of unicity. May we assume that earprints are uniquely associated with the ear that made them? What are the chances of encountering seemingly indistinguishable prints from different ears? The answers to these questions depend on the available variation in prints of different ears, but also on the differences that may occur between various prints of a single ear.

The work presented here deals with inter- and intra-individual variation in earprints. It

should be emphasized that it is not aimed at offering a comprehensive method for the classification of earprints, although a possible method is discussed in chapter 9. This work was also not intended to offer conclusions regarding the value or reliability of earprints for person identification. It was, however, meant to provide a scientific basis from which to embark upon investigating these matters.



# CONTENTS

Preface	7
<b>1. Introduction</b>	<b>13</b>
1.1 General introduction and goal of research	14
1.2 Morphology of the external ear	16
1.3 Variability of the external ear	19
1.4 Recognizing the representations of gross anatomical features in an earprint	28
1.5 Materials and methods	30
1.6 Chapter outline	31
<b>2. Exploratory study on classification and individualization of earprints</b>	<b>33</b>
<i>Forensic Science International 140 (2004) 91-99</i>	
2.1 Introduction	35
2.2 Use of earprints in forensic research	38
2.3 Variability and stability of the auricle	39
2.4 Intra-individual variability in prints	40
2.5 Inter-individual variation: classifying variation and finding diagnostic features	44
2.6 Concluding remarks	49
<b>3. Inter- and intra-individual variation in applied force when listening at a surface, and resulting variation in earprints</b>	<b>51</b>
<i>Medicine, Science and the Law (accepted for publication September 2005)</i>	
3.1 Introduction	53
3.2 Experimental design	54
3.3 Analytical methods	56
3.4 Results and discussion	59
3.4.1 Applied force within a single effort	59

3.4.2	Inter-individual variation in the functional force and peak value	60
3.4.3	Intra-individual variation in the functional force and peak value	60
3.4.4	Resulting intra-individual variation in earprints	64
3.5	Conclusion	66
<b>4.</b>	<b>Exploring the effect of occurrence of sound on force applied by the ear when listening at a surface</b>	<b>69</b>
	<i>Forensic Science, Medicine and Pathology 1(3) (2005) 187-192</i>	
4.1	Introduction	71
4.2	Experimental design and analytical methods	72
4.3	Results	75
4.4	Discussion	77
4.5	Conclusion	78
<b>5.</b>	<b>Cross-sectional anthropometric study of the external ear</b>	<b>79</b>
	<i>Submitted for publication</i>	
5.1	Introduction	81
5.2	Available data on auricle growth	82
5.3	Materials and methods	86
5.4	Results	88
5.5	Discussion	92
5.6	Conclusion	96
<b>6.</b>	<b>Exploring the effect of duration of listening on earprints</b>	<b>99</b>
6.1	Introduction	101
6.2	Experimental design	101
6.3	Analytical methods	102
6.4.	Results and discussion	103
6.4.1	Examination of details	103
6.4.2	Analysis of print-mass	107
6.5	Conclusion	108

<b>7. Preliminary comparison of earprints that were made before and after cleaning the ear</b>	111
7.1 Introduction	113
7.2 Materials and methods	113
7.3 Results and discussion	114
7.4 Conclusion	116
<b>8. Intra-individual variation in earprints</b>	119
8.1 Introduction	121
8.2 Materials and methods	121
8.3 Results and discussion	123
8.4 Conclusion	137
<b>9. Individualization of earprints: Variation in prints of monozygotic twins</b>	139
<i>Forensic Science, Medicine and Pathology 2(1) (2006), in press</i>	
9.1 Introduction	141
9.2 Data	143
9.3 Methods	143
9.3.1 Account of similarities and differences	143
9.3.2 Semi-automated comparison of the position of imprinted features	146
9.3.3 Fully automated comparison of earprints	147
9.4 Results and discussion	150
9.4.1 Account of similarities and differences	150
9.4.2 Semi-automated comparison of the position of imprinted features	154
9.4.3 Fully automated comparison of earprints	155
9.5 Conclusion	158
<b>10. Earprints in forensic investigations</b>	161
<i>Forensic Science, Medicine and Pathology 1(4) (2005) 247-256</i>	
10.1 The use of earprints as forensic evidence	163
10.2 Towards a more scientific basis for earprint use	170

References	183
Appendices	
I Anthropological definition of features in the live ear	197
II Explanation of general terms	199
III Directions for the transitions between the gross anatomical feature zones in earprints	201
IV List of illustrations	207
Summary	211
Dutch summary	217
Postscript	225
Curriculum vitae	227
Miscellaneous publications	228